DOCUMENT RESUME

ED 325 074 IR 014 658

AUTHOR Dwyer, David C.; And Others
TITLE The Evolution of Teachers' Instructional Beliefs and Practices in High-Access-to-Technology Classrooms.
PUB DATE 90
NOTE 48p.; Paper presented at the Annual Meeting of the American Education Research Association (Boston, MA, April 16-20, 1990).
PUB TYPE Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Adoption (Ideas); Classroom Environment; *Computer Assisted Instruction; Computer Simulation; *Educational Change; Elementary Secondary Education; Faculty Development; Hypermedia; Instructional Effectiveness; Instructional Innovation; *Microcomputers; Teacher Student Relationship; *Teaching Methods
IDENTIFIERS *Apple Classrooms of Tomorrow

ABSTRACT

Beginning in 1985, Apple Computer, Inc., and several school districts began a collaboration to examine the impact of computer saturation on instruction and learning in K-12 classrooms. The initial guiding question was simply put: What happens when teachers and students have constant access to technology? To provide "constant access," each teacher and student in the project received two computers, one for the home and one for the classroom. This paper describes the program, Apple Classrooms of Tomorrow (ACOT), and reports on the instructional evolution that occurred in those classrooms. The personal struggles of teachers who came to confront the nature of learning and consequently, the efficacy of their own instructional practices, are examined in detail through individual journal entries. This paper also places the innovative ACOT program in a broader perspective on educational change and draws implications for the support and development of teachers engaged in significant reform projects. (67 references) (DB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

IR

ED325074

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

The Evolution of Teachers' Instructional Beliefs and Practices in High-Access-to-Technology Classrooms

David C. Dwyer
Cathy Ringstaff
Judy Sandholtz

Prepared for a symposium presentation at the 1990 meeting of the American Education Research Association, Boston.

Apple Classrooms of Tomorrow℠ (ACOT℠)
A Project of the Advanced Technology Group
Apple Computer, Inc.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Linda Knapp

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR014658

Abstract

Beginning in 1985, Apple Computer, Inc. and several school districts began a collaboration to examine the impact of computer saturation on instruction and learning in K-12 classrooms. The initial guiding question was simply put: What happens when teachers and students have constant access to technology? To provide "constant access," each teacher and student in the project received two computers, one for the home and one for the classroom.

This paper reports on the instructional evolution that occurred in those classrooms and examines in detail the personal struggles of teachers who came to confront the nature of learning and consequently, the efficacy of their own instructional practices.

The paper places this innovative program in a broader perspective on educational change and draws implications for the support and development of teachers engaged in significant reform projects.

Acknowledgements

The authors would like to acknowledge the contributions of Gina Funaro, Jacqui Giddings, Wayne Grant, Linda Knapp, Connie Troy-Downing, Loree Vitale, and Keith Yocam. Without their dedication, the ACOT project, much less this paper, would not exist. We want to thank the dozens of public school teachers in the ACOT project who are on the line every day, facing full classes, district mandates, and traditional measures. They still manage to discover, grow, laugh, and find the time to share their experiences with us.

This research is supported by Apple Computer, Inc. Views represented in this paper do not necessarily reflect the policies or views of the company.

SAM (A PRIMARY-GRADE STUDENT): "I don't know if we'll have computers [next year]. If we don't, it will be weird. Cause the teacher talks pretty long and you have to listen."

SAM'S MOTHER; "He's really into it—I think computers are just part of our lives now. And it hasn't made Sam any less in terms of wanting to read, or paint or draw. And he's really proud."

SAM'S TEACHER: "I think [computers are] going to help me. It's not going to hurt [students]. I think that they are going to get as much out of working on the computers as they will out of working out of workbooks. I think. But see, I'm not even 100% sure on that."

RESEARCHER: "It appeared that children interacted with each other more frequently while working at computers. And the interactions were different—the students spontaneously helped each other. They were curious about what others were doing. They were excited about their own activities and they were intently engaged.

These behaviors were juxtaposed against a backdrop in which the adults in the environment variously encouraged and discouraged alternative patterns of operating. It was as if they were not really sure whether to promote or inhibit new behaviors." (Phelan, 1989)

Problem Statement

The juxtaposition of these four data points foreshadows the nature of the problem described in this paper. In this instance, a primary-grade teacher has taken the first step in integrating interactive technologies into her classroom. In an interview, her student, the subject of a case study by Phelan (1989), reports his ready acceptance of computers in his classroom. With the guilelessness of the very young, he recognizes that his year has been different by contrasting it to a dreaded return to a computerless room where "the teacher talks pretty long and you have to listen." The child's mother, too, expresses her satisfaction with the computer-intensive program during an interview. But ambivalence enters the picture as the teacher reflects on her year: will her students do as well with the technology as with workbooks? She's not sure. Phelan's observations of this teacher's classroom demonstrate the result of ambivalent feelings in the world of action where potential

innovation is cancelled out by predispositions to the norms of traditional schooling.

This teacher, like all others in the ACOT project, is a volunteer, an eager participant in an ambitious program whose espoused goal is change in instruction and learning. But each member of the teaching staff is also experienced in traditional classrooms as student and teacher. They bring to the program, as part of their personal history, deeply held beliefs about schooling. This paper describes the course of instructional change across the classrooms in the project and illustrates the process to be one of inner conflict. In this instance, the more things change, the more teachers must confront their beliefs about learning and the efficacy of their instructional activities.

Background

Literature on Change and Beliefs

The problem of change in American schools is captured in the title of Cuban's (1990) recent article, "Reforming Again, Again, and Again". The continuing saga of educational reform, characterized by periodic shifts in patterns of practice and values in schools, has observers postulating about underlying causes; critics lamenting the waste in resources; and experienced practitioners steeling themselves against constant assault on the way they conduct the business of learning.

Perennial debate among educational reformers is about control, content, and practice. The control issue is really about the locus of control: Who should be involved in policy decisions? Should decisions be made at the classroom, school, community, district, state, or federal level? Underlying the content and practice issues is disagreement over the very nature of knowledge and learning. From one perspective knowledge is an accumulation of facts and principles that can be communicated to the learner. From another viewpoint, knowledge is personal and must be constructed or discovered by the learner. The first view supports the notion that instruction can be as orderly as science. The second leads to more idiosyncratic views of teaching.

The range of beliefs about what teaching should be can be remarkable and is strikingly portrayed by Greene (1979) in her contrast of the words of B. O. Smith, Dewey, and Buber:

> Teaching is everywhere the same .... In our view, teaching is a system of action involving an agent, a situation, an end-in-view, and two sets of factors in the situation—one set over which the agent has no control (for example, size of classroom and physical characteristics of pupils) and one set which the agent can modify with respect to the end-in-view (for example, assignments and ways of asking questions). (B. O. Smith, 1963, p. 4)

> Education is essentially a social process. This quality is realized in the degree in which individuals form a community group.... As the most mature member of the group [the teacher] has a peculiar responsibility for the conduct of the interactions and intercommunications which are the very life of the group as a community. (Dewey, 1963, p. 58)

> [Teaching is a situation] that has never been before and will never come again. It demands of you a reaction which cannot be prepared beforehand. It demands nothing of what is past. It demands presence, responsibility; it demands you. (Buber, 1957, p. 23-24)

In the first example, one can see the teacher as technologist, practicing behaviors and controlling instructional variables. In the second, the teacher is the creator of learning communities and environments, focusing on social processes. In the last, the teacher recognizes unique moments between teacher and student that present opportunities for growth; he or she works much like a therapist. What may be surprising to some and unacceptable to others is that none of these images of teaching has proven to be superior to any other.

Teaching remains, despite its thousands of years of history, a profession with vague and sometimes contradictory goals (Waller, 1952); with an instructional technology as frequently described as "art" (Lieberman & Miller, 1979), "style" (Lortie, 1975), or "connoisseurship" (Eisner, 1979) as by technique; and with a context that is fraught with uncertainty (Smith & Geoffrey, 1968; L. M. Smith, Dwyer, Prunty & Kleine, 1988). Amidst this uncertainty, schooling remains susceptible to political agendas and value debates. The argument rages on—Cuban (1990) states over centuries—as stakeholders search for an educational Grail or some "one best system" (Tyack, 1974).

In their work-a-day world, teachers must make some sense of uncertainty in order to take meaningful action towards the overarching purpose of schooling, which Metz (1988) defines as helping students "develop

their full intellectual potential . . . while also providing them with academic skills, with an understanding of mainstream culture, and with the ability to participate in it" (p. 451). It is in this *making sense* and *taking meaningful action* that the importance of beliefs and belief systems comes into play. What are beliefs? How does one come to hold them? What are their function?

Rokeach (1975) defines *beliefs* as: "any simple proposition conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase 'I believe that. . . '" (p. 113). Closely allied concepts include *attitudes*— "a relatively enduring organization of beliefs . . . predisposing one to respond in some preferential manner" (p. 112); and *values*—"abstract ideals, positive or negative, . . . representing a person's beliefs about ideal modes of conduct and ideal terminal goals" (p. 124).

Rokeach's perspective underscores several characteristics of beliefs: they are personal and individually derived; they tend to have a long life; and they form the basis for what people believe to be right and wrong in thought and action. Schein (1985), arguing from a cultural perspective, emphasizes two additional attributes of beliefs: they gain potency when shared by groups and they lie deep in the unconscious.

> When a group faces a new task, issue, or problem . . . . someone in the group, usually the founder, has convictions about the nature of reality and how to deal with it, and will propose a solution based on those convictions. . . . If the solution works, and the group has a shared perception of success . . . . group members will tend to forget that originally they were not sure and that the values were therefore debated and confronted. As the values begin to be taken for granted, they gradually become beliefs and assumptions and drop out of consciousness, just as habits become unconscious and automatic. (p. 15-16)

Nespor's (1987) research finds that beliefs play an important role in the organization of tasks and goals when contexts are vague or new. She contrasts beliefs with "knowledge systems" that serve the same function when situations are well specified. Relating the general point to teachers, Nespor states:

> Problems [teachers] encounter, are ill-defined and deeply entangled, . . . beliefs are peculiarly suited for making sense of such contexts. (p. 324)

This point brings us back around to the uncertain business of the classroom and underscores the saliency of beliefs in the study of teacher behavior, especially in the unusual instance of technology saturated classrooms.

Teachers are, by the nature of their work, pragmatists. They must survive the day; they must be ready for the next. Confronted by large numbers of computers or not, they arrive at their classrooms the very first day of their careers with a belief about schooling well in mind, a belief built from stories heard from parents and older siblings, a belief built from years of participating in one particular kind of schooling, a belief that will help them weather the storm of demands they face.

Metz (1988) has called this belief "real school" (p. 449)—"a national ritual experience that provides us a common background" (p. 447). Real school is undergirded by nineteenth-century ideas about "scientific management," itself shorn up by the structures of bureaucracies (Callahan, 1962). Sizer (1984) calls bureaucratically structured schools "pyramids" and writes: "They have become so familiar that any other form of providing for the schooling of young Americans seems unimaginable" (p. 206). At each level of the pyramid, including the level on which teachers and students confront one another daily, the roles and interactions of constituents is prescribed (Raywid, 1988; Timar, 1989).

It is this prescription about schooling, built over years in the minds of those who come to teach and sanctioned by those who already teach, that leads to a seeming contradiction. While those who talk *about* schooling describe its penchant for change, teachers, who *do* schooling proceed about their business in a manner that is remarkably resistant to change. Despite the best efforts of student-centered reformers over the decades, lecture, recitation, and seatwork continue to be the predominant instructional practices of the day. Even in the current outcry for radical restructuring of schools, fundamental change in the content of instruction and in the ways teachers and students interact is most often overlooked (Timar, 1989).

This, then, is the context into which Apple Classrooms of Tomorrow (ACOT) has tread. In its inception, the project's philosophy was to provide technology and actively support teachers in the directions they chose to go. Based on three years of observations, ACOT developed a decided bias towards a constructivist view of learning and began an active program of education and encouragement for its teachers. Although the direction of innovation in

ACOT's classrooms is promising, the pace of change is slow. We saw ourselves in Cuban's (1990) words:

> Another generation of reformers is fighting against a technical, subject-centered form of instruction expressed in mastery learning, measurement-driven curricula, and bookkeeper like accountability. Those researchers and practitioners who herald cooperative learning, active student involvement and the virtues of desktop computers that interact with students, bring new meaning to Yogi Berra's observation: "It's deja vu all over again." (p. 4)

Program Description

Apple Classrooms of Tomorrow (ACOT) is a flexible consortium of researchers, educators, students, and parents who have worked collaboratively to create and study innovative learning environments and implement educational change since 1985. The project is funded by Apple Computer, Inc. and directed by the ACOT staff, within the Advanced Technology Group at Apple.

ACOT's mission is formative: to explore, develop, and demonstrate powerful uses of technology in teaching and learning. As an agent of change, the program seeks to influence educational reform by implementing the following goals as an ongoing process:

- Build active, creative learning environments where children and teachers have immediate access to interactive technologies;
- Study how these environments affect teaching and learning;
- Document and share results with parents, educators, policymakers, and technology developers; and
- Use findings to recreate the vision.

ACOT provides participating teachers and students with ready access to computer-based technologies for the exploration and development of better ways to use computers for learning. It provides its teachers with information about current learning theories and exposes them to new curriculum ideas. As ACOT teachers envision new instructional approaches that use technology, the project provides them with training, consultants, and equipment that allow their plans to be implemented and evaluated.

ACOT also sponsors a number of R&D projects that apply current learning theories in the development of innovative curriculums, tools, and environments. These projects address common problems in learning, such as the difficulties that some students have with organizing their writing or with solving abstract problems. Typically, an R&D team works within a university environment to design and build a technology-based prototype. Then the prototype is moved into a classroom for further development by an expanded R&D team that includes teachers and students.

In order to understand how technology can best support teaching and learning, the project funds university-based researchers to study ACOT classrooms. Currently studies are underway, examining questions that will take a number of years to answer fully. Research questions include: How does immediate access to technology affect curriculum and instruction? How do students' thinking processes change when they use computers daily? What kind of impact does an innovative technology project have on students after they leave the project? What must school systems do to implement instructional change that takes full advantage of technology?

ACOT also promotes change in research procedures by applying new tools for collecting, analyzing, and interpreting data. These tools include the use of hand-held computers for collecting data; new database systems for managing and analyzing numerical, textual, and multimedia data; and new measures for assessing students' problem-solving skills, their application of the writing process, and their understanding of complex ideas.

Over three dozen research studies, R&D projects, and teacher development projects are underway. The following titles of projects in progress suggest the scope of ACOT's research efforts.

- Problem Solving in High Computer Access Classrooms
- The Influence of HyperCard® on Students' Thinking
- Alternative Measures for Assessing Computer Intensive Learning
- Interactive Media to Improve Student Writing
- An Intelligent Tutoring System for High School Physics
- Interactive Learning with Computer Simulations
- Increasing Student Empowerment in Immediate Computer Access Environments
- A Distance Learning Enrichment Model for At-Risk Students

- The Role of Technology in Accelerating Teacher Development

Research Settings, Data, and Methods

This report focuses on events at five ACOT sites over a four-year period. Together the schools are representative of the diverse populations and conditions found in contemporary public schooling. Each of these sites began with one classroom in the fall of 1986, adding classrooms, staff, and students in subsequent years. Table 1 summarizes the status of each site in the spring of 1989.

Site	Grades	Teachers	Students	Community/SES
1	1-4	8	180	Suburban/High
2	5-6	7	180	Rural/Middle
3	4-6	4	90	Inner-City/Low
4	4 & Sp. Ed.	4	80	Suburban-Urban/Low-Middle
5	9-12	9	120	Urban/Low-Middle

Table 1: Site Descriptors

The ACOT classrooms in each of these settings offer students constant access to interactive technologies. The elementary classes are equipped with Apple® IIe, IIGS, and Macintosh® computers. The high school is an all Macintosh installation. In addition to the computers, each class is equipped with printers, scanners, laserdisk and videotape players, modems, CD Rom drives, and hundreds of software titles.

The technology is used as a tool to support learning across the curriculum. No attempt is made to replace existing instructional technologies with computers. By design, the classrooms are true multimedia environments where students and teachers use textbooks, workbooks, manipulative math materials, white boards, crayons, paper, glue, overhead projectors, televisions, pianos, etc. as well as computers. The operating principle is to use the media that best supports the learning goal.

This report draws on a rich, multi-perspective body of data composed of personal reports from teachers; weekly site reports; classroom observations;

interviews with students, parents, and teachers; and assessment data provided by the districts and a cross-site assessment research effort.

Teacher Journals—Teachers record their personal observations of events in their classrooms and their reflections on those events on audiotape, producing on the average two 60-minute tapes per month. The tapes are mailed to Apple where they are transcribed and entered into a database. Instructions about content on the tapes are purposefully left vague, leaving teachers free to report what is most salient at the time to each of them.

Weekly Reports—The teaching staff at each site communicates weekly on major events and developments in a written summary that is electronically distributed among all project participants via Apple Computer's corporate networking system. Again the content of the reports is left to the determination of the teachers at each site. Because these reports are publicly aired to everyone connected with the project, they tend to be more self-conscious than the personal, frequently introspective reports contained in the audiotape journals. Together, these two sources of data provide interesting contrasts on events at the sites.

Both the teacher audiotapes and the electronically communicated weekly reports are monitored by graduate students who digest the source information into discrete "episodes," and index them according to content. Content categories were derived according to the principles of "grounded theory" (Glaser & Strauss, 1967), "progressive focusing," (Hamilton, MacDonald, King, Jenkins, & Parlett, 1977), and "collapsing outlines" (L. M. Smith, 1978). The resulting four-year database contains 13,081 episodes (7,976 audiotape episodes and 5,105 episodes from weekly reports). The indexing system allows sorting and rapid retrieval of descriptive, qualitative data along a number of dimensions for the construction of narrative reports about the project. Important themes and events emerge from the data in the "constant comparison" mode, again of Glaser and Strauss.

Classroom Observations and Interviews—Beginning in 1986, ACOT awarded grants to researchers who were interested in basic assessment and instruction issues and in various problems associated with the introduction of technology to classrooms. These projects, some ongoing for a number of years in the ACOT sites, utilized observation and interview techniques as data gathering procedures (e.g., Baker, Herman & Gearhart, 1988; Damarin & Bohren, 1987; Fisher, 1988; Herman, 1988; Hiebert, 1987; Phelan, 1988, 1989; Levine, 1988; Ross, Smith, Morrison & Erikson, 1989; Tierney, 1987, 1988). These data and

reports provide further, independent perspectives on teacher and student experiences at the sites.

Cross-site Assessment Data—Drs. Eva Baker, Joan Herman-Cooper, and Maryl Gearhart of the Center for the Study of Evaluation at UCLA designed and implemented a three-year, cross-site study of ACOT. Student demographic and psychometric data were collected annually from participating districts, using subsets of the Iowa Tests of Basic Skills and Iowa Tests of Educational Development, the School Attitude Measure (SAM), and the Student Motivation Questionnaire (SMQ). This study is in its third and final year. The project's interim report (Baker, Herman & Gearhart, 1988) provides the final source of perspective for this paper.

A Programmatic View of Instructional Change in ACOT Classrooms

In the early days of the introduction of computers to classrooms, implementers focused on the innovation—computers and software. Little thought was given to the elements that would most likely remain the same—instruction and assessment. There was unbridled hope that the introduction of technology would bring about the same kind of successful transformation that had been seen in science and industry, but goals and means in the education arena were vague.

In many ways the early progress of ACOT repeated the same error. Although the sheer number of computers in ACOT classrooms radically transformed the physical environment, for the most part student learning tasks remained unchanged in the early years. Gradually, however, new patterns of teaching and learning emerged at all sites. It is relatively easy to view this progression as an evolutionary process that is similar to other models of educational change (e.g., Berman & McLaughlin, 1976; Giacquinta, 1973; Gross & Herriott, 1979). We have labeled the stages of the evolution in ACOT classrooms: Entry, Adoption, Adaptation, Appropriation, and Invention. (See Figure 1, p. 22.) In this model, text-based curriculum delivered in a lecture-recitation-seatwork mode is first strengthened through the use of technology and then gradually replaced by far more dynamic learning experiences for students.

Entry. The point to acknowledge in this phase is that an instructional technology already existed in each of the ACOT classrooms at the time the project began. The technology was text-based and the common tools were blackboards, textbooks, workbooks, ditto sheets, and overhead projectors. These tools were used in combination to support lecture, recitation, and seatwork. *Real school*, as earlier discussed, was firmly in place. Teachers, who were beginning their tenure with ACOT, had little or no experience with computer technology and were in various stages of trepidation and excitement.

Prior to the beginning of the school year in 1986, classrooms were rewired and in some instances air-conditioned. Blackboards were replaced with white boards to reduce the amount of classroom dust. Student desks were rearranged into rows or clusters or replaced with modular computer furniture. The first weeks of the project at each site were given over to unpacking boxes, running extension cords, untangling cables, inserting cards, formatting disks, checking out home systems—generally trying to establish order in radically transformed physical environments.

Once instruction began, experienced teachers found themselves facing first-year-teacher problems: discipline, resource management, and personal frustration. (See Sandholtz, Ringstaff, & Dwyer [1990] for a full discussion of classroom management issues.) ACOT staff clearly had second thoughts:

> If I had my druthers, I don't think I would ever look at a computer again. One of my students got into the Corvus network and lost lots of information because he doesn't know what he is doing. It's a typical situation, and it's caused a major problem because now the computers are down. There are so many variables like this that we deal with on a day-to-day basis that I didn't anticipate being part of this program. I'm anxious for the weekend so I don't have to do anything with computers. (AT, 2226, 11/16/88)*

> Study time is a problem time. [Students] think that just because that computer is sitting there, they have to have their hot little hands on those keyboards . . . . They just get on the computer and anything they can call up they have to have their hands on it. (AT,1346, 11/8/88)

---

* Project data is referenced by type: AT = Audiotape teacher journal; WL = Weekly report from sites; and SL = electronic memo sent from site to Apple. The data type is followed by the item's unique identifying number and then the date the item was written or tape recorded.

> There's too much fooling around with the computer—mousing around— when they're supposed to be listening. (AT, 5238, 3/29/87)

> I've found that when the computers are on, the students not using them have a very difficult time maintaining their concentration on whatever else they're doing—even if their backs are to the computers (AT, 2224, 12/2/88)

Adoption. Teachers' struggles to accommodate the new technology seemed to abate during their first year with the project. Computer-based issues were far from over, but the balance of their concerns began to tilt towards using computers rather than connecting them. What we witnessed during this period was the *adoption* of the new electronic technology to support text-based drill-and-practice instruction. Students continued to receive steady diets of whole-group lectures and recitation and individualized seatwork. Although much had changed physically in the classrooms, more remained the same.

Damarin's (1988) study of the project's first year at one of the sites not only recognized a failure to move forward instructionally but documented some of the constraints under which the teachers labored: a district course of study that reflected state-mandates and standardized testing.

> The teachers had long experience and finely-tuned methods of working within these constraints and maximizing their effectiveness in that context; they had little incentive or direction for making changes which might jeopardize . . . performance on existing criteria. Although the district planners sought (and achieved) a plan which serves as a model for equitable implementation of a radically different instructional environment, they did not seek to create new approaches to instructional excellence. (from an unpublished manuscript)

During this phase, one might anticipate significant disruption of student learning while teachers reformulated instructional management strategies and while both teachers and students mastered the many skills and ideas that successful computer use requires. Surprisingly, traditional measures of achievement showed no significant decline or improvement in student performance aggregated at the classroom level, while teachers reported individual students performing better. Self-esteem and motivation were measured and reported to be strong at all sites. Student attendance was up and reported instances of discipline problems in ACOT classrooms ranged

from zero to few. (Beaty, Howell, Shofner & Wilmore, 1988; Kitabchi, 1987; Walker, 1987)

Adaptation. In this phase, productivity emerged as a major theme. Students produced more, faster. In a self-paced, computational math program, for example, 6th-grade students completed the year's curriculum in 60% of the time normally required to complete the course of study (WL, 11006, 3/31/88), and test scores remained as strong as in previous years. The extra time led to increased opportunities for teachers to engage students in higher-order learning objectives and problem solving in math.

In high school science, the instructor reported that students were learning how to write and balance chemical formulas much faster and more accurately than in his previous experience. He wrote:

> It is great to be able to compress lesson time because of the software tools we now have. (SL, 285, 4/22/88)

The chemistry teacher's supervisor also noted change in the efficiency of the instructional process:

> The students have access to the total assignment on the network and are working through it much more quickly and with more understanding. Many of them never use paper and pencil on the assignment at all. They download [the teacher's] handouts to their computers, work on the tasks assigned, and send the final copy of their work to the printer to be picked up by [the teacher]. No more pages and pages of handouts that are lost, replaced, and lost again. (WL, 303, 5/4/88)

Writing was another area that drew frequent comment from the sites in the Adaptation phase. A weekly report from the 4th-grade classroom read:

> I was amazed at the speed at which some of the students could move through various AppleWorks screens. I have noticed that increasingly AppleWorks has become the preferred manner of preparing assignments. Many of the students can now type faster than they can write. (WL, 916, 10/25/87)

ACOT's special education teacher reported:

> Students are writing with a great deal more fluency now, thanks to keyboarding skills. Following a prewriting exercise, they now type their stories directly

> into the computer, rather than writing out the whole story and then copying it. (WL, 1068, 3/2/88)

A six-month study of the writing of ACOT's third graders led to the following conclusions:

> •Children maintained a high level of enthusiasm for and interest in writing over the six-month period [of the research project].
>
> •Computers made compositions much more presentable to others, thus encouraging learning.
>
> •Students wrote more and better as a function of the accessibility of computers. (Hiebert, et al., 1987, p. 2-4)

Increased productivity in the writing area led to a bounty of text that allowed teachers to work with even young students on narrative skills. Willingly, students reworked their papers, a rare occurrence in paper and pencil classrooms. The same outpouring of text overwhelmed ACOT's teachers and led to the need for new strategies for instruction, feedback, and evaluation.

Change in the quality of student engagement in classroom tasks was another notable factor during the Adaptation phase. The following reports are representative.

> We are finding that the students are coming in to use the computers during lunch and staying late to complete their HyperCard assignments for social studies on the countries they are researching. This degree of commitment and engagement is really unusual in a group of quite ordinary kids. (AT, 69, 10/25/87)
>
> On Monday, when I announced that it was time for recess, the students wanted to continue to work in the classroom. One said, "You know, I can't believe it's really recess. When you're having a good time, time goes by so fast." They are really involved. . . . They work really quietly without a lot of running around. They seem to be setting up standards for themselves to judge their own work. (AT, 1817, 9/19/88)
>
> This class is made up of children who had difficulty with the third grade and were not quite ready for the fourth. They are easily distracted . . . . They are less inclined to get off task when working on the computer and less intimidated with math problems than when working from a book. (WL, 1258, 10/21/87)

Appropriation. Movement to this next phase occurred for the first cadre of ACOT teachers in the second year of the project across all sites. Change hinged on each teacher's personal mastery—coined "appropriation"

by Papert—of the technology. Appropriation is the point at which an individual comes to understand technology and use it effortlessly as a tool to accomplish real work. Perhaps, it is best described in the words of two ACOT teachers; the first is on the doorstep of appropriation, the second has crossed the threshold.

> I'm still getting more confident in my use of computers. Seems that my day unconsciously revolves around the use of computers. I do lesson plans, notes and correspondence, report card info., history info., current events—all on the computer. I appreciate how it lets me function better as a teacher, when it's working. I don't think it's more important than any other teaching tool. However, it has a wide variety of uses. (AT, 2208, 9/9/88)

> Last spring, when I was taking a course at the university, I borrowed a computer, and I did my whole term paper on it. I could not believe how labor saving it was and now, I believe, like many other teachers who have discovered the same thing, that it would be hard to live without a computer. If you had to take the computer I have at home, I would have to go out and buy one. I would have to have a computer. It has become a way of life. (AT, 2113, 9/9/88)

The Appropriation stage has been seen in very few classrooms because very few teachers or students have enough access to technology to reach a point where computers become natural tools with which to work (Becker, 1987; Office of Technology Assessment, 1989). Only with immediate access can educators move beyond the limiting view of technology as an efficiency and productivity tool, a narrow and limited view of the tool that often serves as basis for criticism of its place in schools (e.g., Cuban, 1986).

The importance of appropriation for the evolution of instruction can be seen in the following episode where a teacher, holding a vision of an exciting instructional unit, reports that he overcame a highly technical problem. He persisted even after a representative of the company had discouraged the idea.

> I was so excited after the first day, I thought it was too good to be true. The students were using PageMaker to make a publication in a 40-minute class period using the network. It seemed to run about 80% the speed of a hard drive! All students saved and quit with in three minutes before the bell.

> It runs like a charm. . . . Now we can simulate a newspaper company. Eventually, students will work in groups, each with their own task, some for art, business graphs, articles, and the editing group. Students can place finished work on a public share disk for the editing group to retrieve and complete the publication.(SL, 263, 3/28/88)

Technical jargon aside, the point is that this teacher's accomplishment—technical invention—opened a path to a new instructional strategy that would engage his students in a highly collaborative and creative activity.

As teachers independently reached this stage, their roles began to shift noticeably and new instructional patterns emerged. Team teaching, interdisciplinary project-based instruction, and individually-paced instruction became more and more common at all of the sites. To accommodate more ambitious class projects, teachers even altered the foundation of the *real school* day—the master schedule.

One example was a city study that culminated in the construction of a scale model of an urban business district. The final construction sat on a 10 by 20 foot base and incorporated four-foot tall models of buildings and robotic elements run by 12 or more Macintosh computers. The project was led by the computer applications teacher. A weekly electronic memo caught the project in progress.

> The district art teacher will be with the ACOT students the entire six periods, Monday, as they put their model of the city together. The applications teacher has conned the rest of the team into giving up their classes so the students can have a full day of Computer Applications.
>
> This has been a wonderful, integrated activity for students. They are using the robotics they have from Fischer Techniks to build parts of our city such as the traffic lights at Broad and High streets, our center of town, the outside elevator going up the Nationwide Building, railroad crossings, and many more.
>
> The students researched the actual height of the buildings downtown and followed that by doing the mathematical proportions that must be done to determine the heights and widths of the model buildings accurately. (WL, 315, 5/8/88)

The success of this first big event led to subsequent projects the next school year, including an embellished return of the city project that included field trips to specific buildings and research about individuals and businesses that occupied them.

At both ACOT's elementary and secondary schools, this type of teamed, project-based learning activity opened opportunities for teachers to step back and observe their students. What they saw was their students' highly evolved skill with the technology, students' ability to learn on their own, and

students' movement away from competitive work patterns toward collaborative ones. From the sites:

> It's amazing to me how much these kids are learning. . . . Kids are doing things that are not assigned. The excitement is that they are motivated, seeing the power of the things which they are learning how to use, creating for themselves solutions to problems for other things. That is the goal of the educator. That the student be motivated to solve problems important to him, not to go after points. You never see this in regular classes. (AT, 39, 10/3/88)

> The applications teacher asked the students to design a calculator using HyperCard. It was just so gratifying to see that as soon as one student finished they would go look at another student's, saying, "How did you get it to do that?" Sharing strategies: "didn't you do the extra credit?" "You know how to do square root? Let me show you." It was just that sort of give and take, that sort of excitement, contagious enthusiasm, high level of engagement that makes me feel that this really is a good model for the classroom of the future. (AT, 2576, 2/22/88)

> I tried to stand back today and take an overall view of what our classroom looks like. Some students were working on the board with each other in small groups. Sue was working with Joe; they've never worked together before. Joe's mother has talked to me because she's upset that he's not succeeding in the math part of our program. One of his problems is that he is so shy, he just won't ask questions. So, Sue was helping Joe and he seemed to be understanding. . . . I went and asked if she needed help. As soon as I left, I noticed Joe sought her out again for help. I thought, wow, this is something that would not happen in a traditional high school math classroom. (AT, 7205, 2/1/89)

Students helped other students over hurtles with the technology, and they helped their teachers. In the latter class of events, some teachers were a bit defensive at first but seemed to adapt to the more empowered status of the student.

> Students are talking about using the computer for the voting, itself, in our mock presidential election project. They are already using HyperCard and Excel for the registration process and to help in the analysis of data. The students are setting up these programs themselves. Although I know something about Excel and HyperCard, I am not a software expert. But I am an expert in English. (AT, 2119, 9/9/88)

Sometimes, they were more than a bit defensive with the spontaneous peer-coaching. More experienced ACOT teachers, however, defended the concept.

> Our new teacher commented at our staff meeting that he is not comfortable at all with having the students work together. I felt uncomfortable with that last year, but ACOT has broken me away from that feeling, realizing that students can be very productive being instructional aides for each other. We pointed out

> to the new staff person in our program that if a student is having another student do their work for them, it's going to show on the tests. Unlike the normal classroom, students can't just take Fs and go on. They have to go back and take the test until they pass it. Students know that no one can do their homework for them. It's exciting to watch them putting their heads together to learn. (AT, 7131, 9/29/88)

In one instance, the district technology supervisor at one of the schools, observing the extent of peer interaction in the ACOT classroom, noted that by allowing students to teach each other, teachers' roles were changing as well.

> The students really enjoy these group activities and, as we all know, learn more since they are actively rather than passively participating in the learning experience. Our teachers are learning to be facilitators rather than the total dispensers of knowledge. Everyone benefits. (WL, 186, 1/29/88)

The extent to which teachers not only became comfortable with student experts in their classes but actually began to depend on their students is demonstrated in the following quotes.

> Yesterday, a student asked the science teacher how to work with FatBits when using HyperCard. The teacher began to explain a method he used which was pretty involved, when about eight students began saying, "No, no, no. All you have to do is . . . ." The teacher was delighted that now he has supporters who can help him as they discover short cuts with the software. (WL, 200, 1/12/88)

> All the classes are over now but a few of the students are working for us during the summer. Since we have Summer Tech [a technology training institute for teachers], we need experienced people to setup hundreds of computers, etc. at a central location. . . . Several of the students are helping us out there . . . . and a couple of ACOT students are the instructor's teaching assistants. (WL, 483, 6/22/88)

> We have put our kids in a position of creating teaching units in all of our subject areas. Keeping in mind that I have 9th and 10th graders who have pretty good writing skills, the results usually only need a little polishing. (SL, 244, 3/9/88)

Though the above examples came from the high school site, the phenomenon was by no means restricted to older children. Phelan (1989), an independent observer studying one of the elementary sites, also commented on changes in communication patterns and the extent of collaborative work among even the very young students.

> The interactions of children at computers were different. Specifically, the students talked to each other more, they frequently asked for assistance from

> their neighbors, they were quick to interrupt their own work to help someone else, and they displayed tremendous curiosity about what others were doing.
>
> Lines of communication ran between children and computers and between children rather than between the children and the teacher. The work mode orientation was frequently cooperative rather than individualistic. Interestingly, the teacher expressed delight at the amount of cooperative learning that took place: "I could never have anticipated that much cooperative learning going on. Some of it's screwing around, but a lot of it is helping each other. I just think it's wonderful. I mean, it drives me crazy when I'm trying to work on a reading group and they're back here chatting away and I do my share of, 'You will say nothing else.' But I'm really pleased." (p. 6)

ACOT's elementary teachers also added to the evidence.

> The big excitement over the past week with the children has been the introduction of LogoWriter. I happened to come in while the students were working on it and was immediately mobbed, as were the other teachers in the area—not with inquiries for help, as might be expected with the introduction of new software, but rather with pleas to see what each of the students had discovered on their own. It was one of the most exciting times we've had in our classroom this year. (WL, 985, 4/29/87)
>
> Susie N. and David S. are working on Animate and Write Connection. They are doing some amazing things. David especially is impressing me with his ability to get into something. He's already more adapt with the animation disk than I will ever be because I won't take the time he has to learn it. I always want the kid to be the expert. Susie is very competitive with David and is always looking to get an edge. Seeing the two of them work with each other in friendly competition is a pleasant thing to watch. (WL, 5761, 12/1/88)
>
> I gave Billy the Animate disk that wouldn't save [a file] and told him to see what he could do at home over the weekend. He solved the problem. We just weren't completing the path name. I should of thought of it, but I'm glad that Billy figured it out on his own. (AT, 5766, 12/5/88)
>
> The long-awaited newspaper that ACOT 4 has been working on was finally published last week. This has been an ongoing effort for over 6 weeks. The final product was total student effort. It was their job to learn the software and the various ways in which it could be used. I was quite proud of their first effort, but I was even more proud of the way in which the entire class participated in a group discussion of how to improve the paper next time. Every single change that I would have suggested was made by the students. I am convinced that they are their own best critics. (WL, 13009, 4/6/89)

Again, the critical event that triggered this most dramatic change at the sites is the personal appropriation of the technology tools by individual students and teachers. As noted, the first cadre of ACOT teachers and students acquired this level of competence after more than a year with the project.

Importantly, the second cadre of teachers accelerated through the evolution in a matter of several months. Explanation lies in their ready access to teachers and students—local experts—who had already appropriated the technology.

Perhaps most important in this phase was an increasing tendency of ACOT's teachers to reflect on teaching, to question old patterns, to speculate about the causes behind changes they were seeing in their students. At the beginning of her third year with the project, one of the project's high school English teachers recorded the following:

> I love walking through the math class this year. It is all individualized and there is such a business-like hum going on; there is such a good feel to it. It seems like what schools ought to be.
>
> Being on hall duty this year, I have a chance to hear how, in class after class, the teachers' voices drone on and on and on. There is very little chance for the student to become an active participant. In today's schools there is little chance for the individual teacher to actually change the curriculum, but we can make the way we deliver the curriculum very different. And that's where the technology comes into play: to make it more interactive, to encourage collaborative learning, to encourage exploration. The technology can adjust to fit the curriculum, I think, whatever it is. (AT, 1378, 10/11/88)

A segment from the journal of one of the project's elementary teachers exemplifies not only reflection as an aspect of appropriation but the ability to speculate about the future.

> This morning I had [the students] continue illustrating the first chapter of whichever book they've been reading. I want between three and five drawings. I have one group which I think is exceptional. One of the kids shows some real talent and I'm trying to give him some special instructions in using MacPaint if I can find somebody who's good enough to do it. He's far beyond anything I can do for him.
>
> I'm beginning to see some reading types of things we can do with Hypercard for next year. . . . Once we get some good drawings, we can start putting [into the computer] some drawings and text and come up with a basic outline of each book that we have in inventory. That's going to take several years, but I believe that by the time we get through, we will have an outstanding reading program. We will expose the kids to lot of high-quality literature and we will have made some good use the equipment, such as the scanner and laser printer, as well as some of the other things, too. It's beginning to come together. I've griped about reading all year long, but I'm beginning to see some things that won't be brought to fruit this year. It's too late in the year, but there's some possibilities now that we can exploit well next year. (AT, 1589, 3/10/89)

Invention. The final stage in this model of instructional evolution is really a placeholder for further development by ACOT's teachers and for the new learning environments that they will create. Entry, Adoption, Adaptation, and Appropriation can be viewed as stages that build a readiness for purposeful change. In the earliest stages, ACOT teachers demonstrated little penchant for significant change and in fact, were using their technological resources to replicate traditional instructional and learning activities. During Appropriation, however, they seemed to gain a great deal of perspective on just how profoundly they could change the experience of learning for their students.

The last two teacher quotes communicate a working comfort with beliefs about teaching and learning that were not common among the staff at the project's outset. Though variation exists, the staff of ACOT's classrooms are more disposed to view learning as an active, creative, and socially interactive process than they were when they entered the program. Knowledge tends to be held more as something which children must construct and less like something that can be transferred intact. The nature of these teachers' classrooms, the permissions they have granted their students, and their own instructional behaviors demonstrate that shift in action.

As an aggregate, this retrospect of four years of ACOT history accurately depicts the overall direction of instructional evolution across the sites. But it eludes the less rational, idiosyncratic paths revealed by more detailed chronologies of the teachers' experiences. If the model, depicting changes in the classroom behavior of these teachers is also indicative of teachers' changing beliefs about teaching and learning, it appears that the movement from one belief system to the other is not orderly, unidirectional, or perhaps, ever final.

If Cuban (1986) is right about teachers being the gateways to change—and we believe him to be—attention to these stories will offer far richer implications for successful implementation of planned innovation. The next section presents two, more detailed cases from the personal accounts of teachers in the project. While the overall direction or general flow of change remains the same, these individuals' stories show countless eddies and whirlpools all along the way.

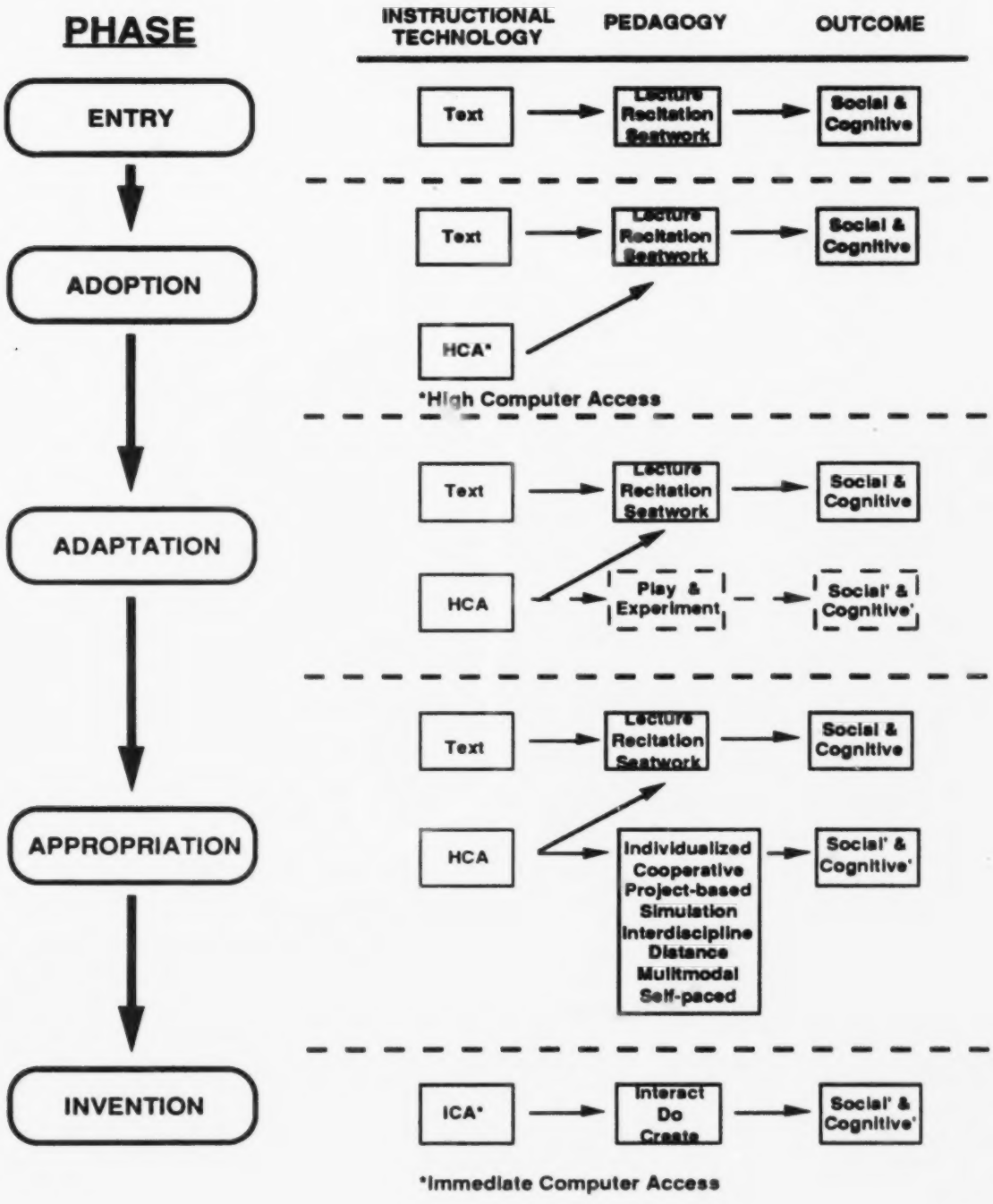

Figure 1: Instructional Evolution in Technology–Intensive Classrooms

Views of Individuals in the Process of Instructional Change in ACOT Classrooms

> I guess I have to realize that what I am doing is learning how to undo my thinking. (AT, No I.D., 9/28/89)

This reflection by one of ACOT's teachers aptly introduces the fact that movement from Adoption to Invention is not an easy passage. The following episodic accounts of two teachers' experiences, based on their personal audiotape journals, indicate that the process was ridden with self-doubt, subject to external influence, exhausting, and never unidirectional. Most teachers entering the program believed that technology would make their jobs easier and more efficient. Most never dreamed they would alter their instructional approaches or broaden their perspectives about what children should and should not, could and could not, accomplish in their classrooms. The words of one teacher described the experience of many:

> As you work into using the computer in the classroom, you start questioning everything you have done in the past, and wonder how you can adapt it to the computer. Then, you start questioning the whole concept of what you originally did. (AT, 5857, 12/8/88)

This kind of questioning led to the experimentation described earlier in the Appropriation stage. Successful experiments led to more experiments. Failures led to setbacks, even temporary cessation of new strategies. But fundamental alterations in these classrooms—the intensity of student engagement, the extent of collaboration, the presence of the technology as a symbol of change—had their own sort of momentum. Inexorably, teachers seemed drawn back to further exploration, while students collectively influenced events as they always do, expressing pleasure and displeasure clearly and persistently.

The direction of change was towards child-centered rather than curriculum-centered instruction; towards collaborative tasks rather than individual tasks; towards active rather than passive learning. Each of these dimensions brought deeply held beliefs about *real schools* into conflict with what teachers witnessed in their classrooms. The conflict never transformed those beliefs outright; the process seemed more gradual: an erosion of the old,

an accretion of the new. During this process, teachers' actions would first swing one direction and then the other.

In the following case of a fifth-grade classroom, Mrs. Smith noticed increased student engagement when children had more choice and when lessons were less "teacher directed." She was anxious, however, because student engagement was tightly coupled with computer use and student collaboration, which she associated with movement and noise. Movement and noise conflicted with her belief in classrooms as quiet and orderly places. The result is a story of vacillation.

Mrs. Smith: 5th grade

Mrs. Smith is a 5th-grade teacher in an inner-city school. In the first month of the project, she reflected on a lesson on cells and worried that her approach was too "teacher directed." Given her unfamiliarity with computers and software, however, she said that the students were going to have "to get used to following instructions" (AT, 6416, 9/9/86). She established a familiar routine over the first three weeks of September, wherein she would present a lesson and then allow children to use their computers for individual practice and reinforcement drills. But she reported a small variation in the third week that resulted in increased student engagement.

> I struck on a new idea for the computers. Rather than use it as a follow up on text or teacher presentations, I have the children at their computers and have them turn off their monitors while I present, but I allow them to return to working on their own machines as the lesson progresses. I feel pretty good about using the software in this way. Attention is improved and every child is involved. (AT, 6632, 9/22/86)

From this small success came several experiments. In the next several months, Mrs. Smith established a "free period," during which children could select any software they wanted to work with. She began small group instruction, which meant that children worked more on their own. Finally, she suggested a class newspaper project and allowed the students to choose editors and reporters and in large part, run the activity.

But by early December she expressed a concern, one born from her knowledge that there was a set of curriculum objectives for which she was responsible.

> I would feel a lot more comfortable about some of the things that I do if I just knew that before the end of the year I really was going to be able to meet all the objectives and all the things that these children will need. (AT, 6344, 12/2/86)

On the heels of this concern, free choice during "free time" ended abruptly:

> No more game type programs in school as not enough time for this style of learning activity, which is noisy and creates too much excitement. It's become a problem instead of an asset, so I figured the best thing to do is get rid of the problem. (AT, 6346, 12/3/86)

The newspaper project fared better because she saw very positive student outcomes: among them responsibility, skill development, and children helping children.

> The students are new to group discussion and group decision-making. The class chose students with appropriate skills for editorial jobs on the paper; they are doing a good job with writing articles, making use of appropriate sections of language text. (AT, 6350, 12/3/86)

> Children are beginning to incorporate typing skills into their writing activities, turning out longer sentences and correcting errors. (6351, 12/3/86)

> Several children are writing more than one article. Considerable creativity and good self expression is evident, but many errors will require careful proof reading. Students are correcting one another's work before publishing it with *Newsroom*. AT, (6356, 12/3/86)

> Format is getting better as children proof read each other's work. Overall writing is improving. I think it has to do with the fact that they're just writing more. (AT, 6362, 12/3/86)

By mid December, it was common to see children working together on projects in Mrs. Smith's classroom. Children were more active. There were often several different curricular activities simultaneously. Children were given more responsibility and exercised more choice. Reflecting on the status of her classroom, Mrs. Smith noted:

> Old teaching friends were swapping "horror stories" about this year's problems, but the ACOT room has none to offer. A parent also reported stories of problems in another school's fifth grade. Not everyone in the ACOT classroom is perfect, but I do not have the discipline problems that I have had in the past or that my friends are having this year. And I think the factor that I would say made the difference is the computer. Students are getting positive feedback, immediate feedback; they're busy; the work is more appropriate because they

> have varied activities. I have more time to deal with problems. (AT, 6368, 12/6/86)

This report is so glowing that one might assume smooth and continuous progress in the instructional change effort that Mrs. Smith was implementing. But immediately after the winter break, she made an abrupt about face. Her tapes reported discipline problems and her need to control the class. She even questioned the need for students to work together.

> Children don't pay attention. The non-listeners can't pass a quiz on the vocabulary just discussed. (AT, 6371, 1/5/87)

> Perhaps some students would stay on task better with a cubicle arrangement during individual work time. (AT, 6374, 1/ 5/87)

The lapse was momentary. Less than a week later, Mrs. Smith reported on a particularly satisfying science class, where again, children were working together, actively involved in the lesson, and working at their own direction.

> I felt like there was real thinking going on. Once they completed one of the birds they had no problem going on and doing the rest of them. Great help with classification skills. Children are very involved when they have to search for and enter information into their database. Every child in the class is involved. (AT, 6383, 1/ 6/87)

She also noted that there was a price to pay for "involvement"—lots of youngsters who wanted help at the same time. She wished that she were "about ten different people at one time." With that comment, however, she also mentioned that "neighbors can help each other" (6384, 1/6/87). But in action, this principle leads to noise and movement. As the days passed, both became dominant themes in Mrs. Smith's thoughts.

> Children are somewhat noisier as they become familiar with the equipment, and they talk a lot. Some of the moving about routines could be smoothed out to keep a good learning environment. There are many management changes with computers, disks, new and unfamiliar responsibilities for both students and teacher. (AT, 6398, 1/ 7/87)

"Good learning environment" harkens back to images of *real school*, and in only a few days Mrs. Smith, again, questioned her direction and made a turn towards tradition.

> Lots of noise results from the interaction of computer activities: children talk, move around more than in conventional classrooms. Keeping noise and movement controlled is necessary. (6411, 1/ 10/87)

> The availability of software at individual workstations gives students too much control over what they elect to do. Some students choose to do things that are not relevant at the time. The software can be very tempting. (AT, 4549, 1/ 10/87)

She followed these observations with a return to whole group lecture and recitation activities. With satisfaction, she noted that her youngsters were again still and quiet.

> I see most improvement in the students' abilities to sit still, listen attentively and enjoy stories. (AT, 4552, 1/ 13/87)

Real school had returned with a vengeance: with it came a period of insurrection met firmly with an assertive discipline program.

> Misconduct is a real problem. I've been working very hard on a new discipline program. Consequently the children have been very unhappy. (AT, 4558, 1/ 17/87)

The discipline program involved checks for misbehavior and the award of tokens for correct behavior that could be cashed in for small prizes. As part of her program to get the classroom under control, she also implemented a new schedule of activities that would keep her students together and moving at a faster pace, or so was her intent.

> I am structuring software activities that last approx 20 minutes. They will have 3 changes of activities in the post lunch hour. Typically, this hour has been most difficult to keep kids on task. The kids were asked to keep track of the 20 minute intervals. I feel the need for more structure. (AT, 4579, 1/ 20/87)

She noted, however, a problem. One particular piece of software that she used in conjunction with social studies was very popular. Unfortunately, the software was seen as the problem, not the restrictive time schedule. As a result, some children were not permitted to use it. Meanwhile, she continued to report worsening discipline problems.

> It seems that some students always want to be creative. Even though the writing assignment may require specific form (letters, slanted writing) some students want to deviate. There are appropriate and inappropriate times to be creative. (AT, 4581, 1/ 20/87)

> Things went fine until language class. The assignment was to write a business letter. When it became time to print, the noise level got out of hand. There will have to be some kind of control during printing. (4594, 1/ 21/87)

> A classroom of 30 students with one teacher and no aide is too much. This is especially true when required events are less structured. Either the class size needs to be smaller (closer to 20) or the teacher needs to have a full-time aide. (AT, 4595, 1/ 21/87)

In late January, Mrs. Smith again questioned her direction. Things were not going well. The classroom, she admitted, was not like it was in the past, and she needed a different kind of response from children to keep it working. She was once again drawn to think about students working together and taking more responsibility, and she began to open up her class once more.

> I will have to change some of the assertive discipline behavior plans that worked so well last year. Last year the children were not allowed to speak without raising their hands, and had to ask permission to leave their desks. But now, the students are interacting with each other about their software. They are helping each other. I need this kind of cooperation. (AT, 4598, 1/ 22/87)

Although Mrs. Smith felt a need to change her approach to discipline, she still had trouble tolerating children leaving their seats. But when one child walked over to read a new chart on the bulletin board, she reported not having the heart to put the student's name on the board and take away her reward for the day. Mrs. Smith's rigid adherence to her assertive discipline program faded away.

At the same time, her log reports chronicled larger, more ambitious task designs for her students. Once again, she created opportunities for her students to work together for extended periods of time, and she gave them increased choice of tools with which to work.

> Students searched for information on manufacturing goods in the Mid Atlantic states. They didn't finish during the class period. They had the option to use other programs (*Type, Carmen, Amazing Reading Machine*). I was pleased to see that most kids chose to finish their database search. They really enjoy collecting info that way. The slow kids seem to enjoy it, too. (AT, 4679, 1/ 29/87)

The class newspaper reappeared in her notes. Under the banner "Good Things Happen," she proclaimed progress even though "noise" still troubled her.

> The newspaper articles show progress. I proofed the articles and found only one comma missing. The kids are working well together. They are a bit noisy, though. The noise level interfered with a reading group. (AT, 4785, 2/4/87)

Apparently, things were going so well that remnants of *real school* began to bother Mrs. Smith as much as noise. She reported:

> The dumb reading groups are my biggest pain. These groups interfere with computer activities. I wish there was some way to restructure the school day to avoid the 20 minute reading circles. There must be another way to teach reading. (AT, 4786, 2/4/87)

Her enthusiasm continued:

> Today I had an experience that I've never had before—everyone was on task. They had a task on *AppleWorks* which required them to add "-est" extensions to words. Everybody was working merrily away. Brenda was sucking her thumb with one hand and typing with the other. That was quite funny. I asked a friend to video this because it had never happened before. The kids were just typing away. All you could hear was the sound of the typing keys. It was really wonderful. (AT, 5110, 2/11/87)

These successes seemed to herald a new day for Mrs. Smith. On the same tape two further episodes communicated a subtle change. In the first, yet another opportunity for "commotion" appeared as her students began to assert themselves. Where this might have been met with strong resistance before, Mrs. Smith seemed to step aside as an observer and reflect that this latest development in student behavior might be a problem for other teachers. In the last episode, she even offered advice to future teachers about "student freedoms"—almost as if those freedoms were inalienable rights.

> The kids like to print things. They like to print whatever is on the screen. There is competition to use the printers. Some of the kids have become self-appointed experts that oversee the printing of others. At times printing results in minor conflicts. Printing creates lots of commotion. Regular teachers will object to this. (AT, 5132, 2/11/87)

> Using the printers requires students to break out of regimented behavior patterns. They are not used to such freedoms, which creates lots of commotion. Teachers will have to train students to deal with these freedoms quite early. (AT, 5133, 2/12/87)

Mrs. Brown: 9th- and 10th-grade Math

Mrs. Brown is a high school math teacher who joined the project in its second year. She found success with an individualized approach to instruction despite a stubborn belief in the teacher as the source of knowledge. Early in her first year with the project, she took time to observe a more experienced ACOT teacher's classroom and noted a difference from the traditional environments in which she had worked:

> I watched the application class and saw that I really have 30 teachers (students) in my class and I should use them. (AT, 6899, 10/9/87)

Despite her recognition of her students' skills, she worried for months about her lack of expertise and what her students would think of her. It was hard to abandon the image of herself as the authority in her classroom.

> I'm uneasy about the kids' response to me when I'm working with the computers and don't really know what I'm doing. . . . You wonder what the kids will think if they know more than you do. The students have never held their knowledge as a threat, and they are great at helping me. It's something in myself that I'm uncomfortable with in this situation. (AT, 6779, 12/4/87)

She also noted that the technology brought it's own set of issues, one of which challenged her beliefs about students doing their own work. It was an observation that made her less than enthusiastic about collaborative work, but one that would change radically in the coming years.

> I noticed that in the applications class, students were exchanging disks, copying database work and turning in the same work. Is cheating made easier by the computer? (AT, 6918, 10/2/87)

She implemented what she knew best: a lecture-oriented program where new topics were presented, students took assignments home, and returned the next day to have their work checked. But she was unhappy with the results:

> The kids are bored. They're doing their homework from other subjects when I am teaching. (AT, 6782, 12/11/87)

In mid December, Mrs. Brown presented the students with an alternative to their diet of math lecture and recitation. The change brought an immediate

response from her students and opened Mrs. Brown to new ways of thinking about instruction.

> When I started showing the kids how to assemble their string art projects, I expected to have to explain it to each individual kid. What happened was that I explained it to one kid and then the rest got together and figured it out together. They're so used to working with each other that they don't hesitate to figure out assignments together. I've never seen this happen before—it was great to watch them work together. (AT, 12273, 12/18/87)

> I've just realized, on the day before Christmas vacation, how my class is very work oriented. In the past it was a fight to teach before Christmas break but with this class, there's an attitude of work; they expect to keep busy. These aren't extraordinary kids, they're "average" high school kids. What a difference!! I don't know what it is about this program. (AT, 12271, 12/18/87)

Returning from winter break, Mrs. Brown continued to work more with small groups. Although she was generally pleased with students' progress, she had a difficult time shaking the feeling that she wasn't really teaching. The word "guilty" enters the record for the first, but not the last, time.

> I'm concerned about what's happening in Algebra and Geometry, so I guess I'll use the tape as a sounding board. When I try to be objective about it, I feel like I'm spending less time up there teaching. We now have disks for some lessons, which I refer the students to. I know they're learning very well with the computer. . . . I feel a little guilty, it's a strange sensation. (AT, 2919, 1/11/88)

Fewer lectures and more small group assignments brought her closer to her students. The fact that she was closer to the action began to change her perspective on what happened when children put their heads together. Growing trust was followed by more risk taking.

> I feel like I'm focusing more on the students now. . . . It's exciting to see them all helping each other. It's so natural for them to just lean over and check what they're doing with each other. The computers have forced a socialization that I'm sure the students aren't even aware of. (AT, 2929, 1/26/88)

> Today we just experimented with graphing with Excel and some other functions. It's the first time we've all just played with the software to see what it'll do. It was really rewarding because the kids and I were willing to experiment. Usually I want to know what's going to happen so I don't mess anything up or waste time. (AT, 2930, 1/28/88)

By February, there was an obvious shift in Mrs. Brown's attitude about group work. She had set out to change the way she taught, and she had also begun to glimpse the size of the task.

> My God, I'll tell you, I feel like I'm not doing a good job. But it's all work on my part. I read the history of math every morning at breakfast and spend every free moment planning. There is so much more I want to do with my kids—to present lessons in a neat, experimental way. (AT, 2594, 2/4/88)

She reflected on the results of her efforts and found problems but enough success to pull her on. She justified an occasional lecture. She also examined her difficulty "letting loose of being the authority."

> My idea is to occasionally be the general instructor in the familiar and traditional way when that is appropriate, but I am interested in individualization and I'm excited about it but I'm hesitant about it. It's hard to let loose of being the authority, and that's what we're familiar with and the way we were taught. (AT, 4384, 3/9/88)

Mrs. Brown received a jolt from a substitute teacher, a retired, experienced hand, that placed new and old beliefs in conflict, once again.

> My team teacher was out with sick children today and they sent a sub, which they don't usually do. He was a retired science teacher with a very different and serious attitude, and he commented that the classroom atmosphere was much too loose. I punished the one student that really talked out of turn, but the substitute made me wonder if we really were too non-traditional. (AT, 4391, 3/23/88)

The sting of the criticism lasted for weeks and appeared in her account as fear, doubt, and once again, guilt. But even in those expressions, another part of her argued for the collaborative, student-centered vision of teaching.

> I feel guilty when I let the students work in groups for fear they will just play around. But they did a real good job today with their Hypercard stacks in geometry, in spite of the beautiful weather and the approaching spring vacation. (AT, 12544, 3/30/88)

By the end of her first year in the project, Mrs. Brown had worked steadily at changing her instructional behavior, but nagging doubts persisted to the end.

> One thing I have had a hard time with as a traditional classroom teacher is to let them go, let the students try a new way. I find myself falling back into the old way because it's easier and saves me time. Yet I'm not satisfied with lecturing to the students, and I really look forward to planning ways to take advantage of the alternative teaching styles available to me. (AT, 2963, 6/2/88)

Mrs. Brown returned from vacation with a totally revamped math program. Over the summer, she had worked with another math teacher to develop an individualized algebra I, algebra II, and geometry curriculum that she would team teach with a new member to the ACOT staff. Her first report contrasted dramatically with the kids-who-work-together-must-be-cheating attitude that she had held at the beginning of the previous year.

> We started the individualized program today. . . . I praised two students who were talking over the work between themselves, which surprised them. It is going to take a while to get across to the students how this goes. (AT, 2285, 9/7/88)

But the very next day, she recorded the following comment that shows the tenacity of habit.

> The program is going really well, but today I just got sick and tired of explaining the same thing twenty or thirty times, so I just stopped the geometry class and just lectured to everyone in geometry on the same questions that I was getting from everybody. It seemed to work out real well. (AT, 2287, 9/8/88)

Retrenchment began again. Later, with fresh energy, Mrs. Brown redoubled her efforts to change the norms of her classroom. By mid December she was voicing a new confidence in her individualized, collaborative approach. One statement of that new confidence came as a reflection on her participation in a staff development workshop:

> One question that occurred was, don't students cheat and look at each other's screens. I defended the students looking at each others work. They learn by seeing what others are doing and I encouraged peer interaction and peer group work. They thought that was interesting because they haven't used the computers enough to realize this. . . . I pointed out that it takes a while for students and teachers to learn that students can work together, because we are used to the traditional classroom. I was preaching in favor of the things that I was hesitant about on individualized study. I do not have to be in front of the class at all times. It made everything gel for me, and I was pleased with that. (AT, 5862, 12/8/88)

The following week, she entered the following manifesto into her log.

> I think about the way I taught in the old days, three years ago. Lecture, summarize, give examples and assign homework. In each class the students only worked on problems at home and then came back with questions, which I would ask for at the beginning of the period. I dreaded the routine. I loved test days when I didn't have to do anything. I think about how differently I do things now, with ACOT and the individualized program. I could not go back to the old way. I will always keep this individualization with me, even if I went back to a regular class room. Many kids can learn on their own, and many can take responsibility for instruction. I am seeing their capabilities as I have never seen them before. (AT, 5869, 12/13/88)

During the second semester, Mrs. Brown began fine tuning her approach. She looked for ways to combine the best that she had known from her traditional days with her new goals. Overall, she reported success after success.

> The week is over and I feel good about all that is going on. I am not threatened any longer that what I am doing in class is a waste of time. I was weary of the problems of teaching new applications. But I see what the kids are getting out

> of it now, how the thinking process works, and that they are not being short changed at all. They really are learning. (AT, 5704, 1/6/89)
>
> They all got 100%! So the review session they had amongst themselves must have been unbelievable, and it didn't even take them longer than fifteen minutes. It is so exciting to see that these kids can learn from each other, that they don't have to have a teacher standing over them at all times. I'm overwhelmed, but on the other hand, they're learning without my help, and it's a little of a shock to get over. (AT, 7789, 3/30/89)
>
> The tenth grade took the test today, and all of them passed it and mostly with nineties. And this after I gave them holy heck because not one person asked for help after I gave them the preview on the network last week! Now I'm going to have to eat my own words. (AT, 9207, 5/30/89)

At the risk of redundancy, one last quote illustrates that old patterns emerge again and again, even after continued success with the application of new behaviors. Their appearance surprises even the perpetrator. The following is taken from Mrs. Brown's 1989-90 journal.

> I lectured and summarized and felt like I was talking to a wall. It's interesting how I go back to a straight lecture situation, after the kids have been involved in so many group activities and getting their brain cells to work during class, and all of a sudden they just sit there like vegetables. It's yucky to see them sitting there looking at me. (AT, No I.D., 10/2/89)

Vacillation: The Rule, not the Exception

These cases show two teachers in very different settings vacillating between traditional approaches to instruction that had worked for them for years and new patterns of instruction that seemed somehow more appropriate in their technology altered classrooms. In the first instance, Mrs. Smith worked through the fall to develop activities that her youngsters could accomplish in groups and noted with pride their cooperative behavior and achievement. After the winter break, she momentarily worried about classroom control, but she recognized "real thinking going on" and "neighbors help[ing] each other." By the second week of January, those observations were lost in her concern over the noise and movement that resulted from the children's cooperative efforts. The record showed a reactive return to whole group instruction and the implementation of an incongruous assertive discipline program. She was briefly pleased with the result: students were once again passively listening to "stories." By late January, however, she realized that the "assertive discipline behavior that

had worked so well last year" was not working in a classroom where she had to depend on students "interacting with each other about their software" and "helping each other." With the simple admission "I need this kind of cooperation," Mrs. Smith, once more changed direction and legitimated opportunities for the students to work together.

Her pedagogic swings were the result of an inner conflict between how she believed classrooms should function—sound and look—and how she experienced instruction in a radically altered classroom where students each sat in front of a computer with boxes of software. Her students were motivated to learn with those tools, and they had acquired a great deal of skill in doing so. The children, themselves, challenged old assumptions, not through insurrection but through steady pressure to work at those things that were fun and useful. It was not easy for Mrs. Smith to accept that old patterns no longer applied.

In her instance, a cycle was created in which she initiated an innovation that led to both intended and unintended outcomes. These outcomes made her world more uncertain, raising her personal anxiety, which led to questions about the basic premise on which she based her attempts to innovate. She reduced the dissonance by returning to behaviors that were consonant with her beliefs but then encountered resistance from her students, who preferred the more innovative activities to the traditional ones. Moving to reduce this source of dissonance, she would, again, attempt a more innovative path until her anxiety level rose once more. The process was exhausting for Mrs. Smith and contributed to her retirement from the ACOT project after her first year.

Mrs. Brown followed a similar path, full of switchbacks, between a tradition-bound, lecture-based curriculum and an individualized approach that benefitted from spontaneous student collaboration. Her feelings and instructional behaviors pivoted as she tried to resolve the dissonance between her conservative beliefs about learning and teaching and her own experiences with students in the peculiar, computer-filled classroom. Although the process was equally challenging and exhausting, Mrs. Smith did not leave the project. In fact, she seems to return year after year with increasing pedagogical strength and certainty about her direction.

There was a significant difference in the contexts in which these two women strived to change. Mrs. Smith taught in a traditionally organized

elementary school; that is, she worked in a self-contained classroom with little to no opportunity to watch other teachers or even discuss what she was attempting to do. In fact, she believed that colleagues and administrators, even her family, were critical of her efforts. Mrs. Brown, however, entered the project in its second year. The first-year staff had established strongly held values about joint planning, team teaching, and interdisciplinary instruction. Mrs. Brown, by the nature of her context, had constant opportunity to watch other teachers in action and to talk with them informally throughout the day. Both her principal and the district technology coordinator routinely praised the program and its directions. In the first setting, Mrs. Smith succumbed to the shear weight of her effort; In the second, Mrs. Brown flourished, despite periodic setbacks. This pattern, though not as stark, is suggestive as an explanation of differences in rates of change in other ACOT sites as well.

Implications

The idea that deeply held beliefs can stand in the way of change is hardly new, but it does tend to remain an academic notion (Baldridge & Deal, 1975; Cuban, 1986; Fullan, 1982; Giacquinta, 1973). The purpose of this paper is to add to the evidence that teachers' beliefs about instruction and schools is an important factor that underlies the institution's resistance to change and to argue that this fact must inform planning and implementation of significant change efforts. This issue gains bold relief in a program where teachers are personally dedicated to the investigation of the potential of modern technology but are held in check by the principles of 19th-century instruction.

Various authors treat the intransigence of beliefs as immutable (e.g., Nespor, 1987; Schein, 1985). Others are only slightly more optimistic. Nisbet and Collins (1978), for example, reported:

> At the point of implementation, it is not easy to change educational principals and methods which are well entrenched and sanctified by tradition. (p. 243)

Difficult or not, some change theorists hold to a strategy they term "normative-re-educative" and maintain that change in practice occurs only

after men and women change their beliefs and values (Chin & Benne, 1961; Giacquinta, 1973; Paul, 1977).

Fenstermacher (1979) argues that this form of re-education can be accomplished by getting teachers to reflect on their beliefs in the light of reasonably objective feedback about their actions and the consequences of their actions. The difficulty with this very rational view in the applied world stems from the nature of beliefs, how they form, become routine and habitual, and eventually pass from consciousness. Nespor (1987) states:

> When beliefs change, it is more likely to be a matter of conversion or gestalt shift than the result of argumentation or a marshalling of evidence. (p. 321)

Before teachers can reflect on their beliefs, then, they must somehow bring them to a conscious level, and they must see and understand the connection between their beliefs and their actions. They must also be aware of alternative belief systems and have experienced the consequences of those beliefs.

If beliefs are beyond direct manipulation by the sponsors of change, as theorists argue and experience seems to indicate, what can be done to foster the generation of values and attitudes that support innovations? Our reflections on ACOT's experiences suggest that structural and programmatic shifts in the context or working environments of teachers who are instructionally evolving is critical to the eventual outcome of their struggles. Further, recognizing that change is evolutionary, we suggest an incremental approach to physical alterations of the context and a progressive shift in the type of support for teachers passing through Adoption, Adaptation, and Appropriation.

In the instance of integrating computer-based technology into K-12 classrooms when fundamental instructional change is the goal, the recommendations listed in Table 2 seem prudent to speed and ease the transformation. Note that the nature of the recommended support for teachers in this process changes as they move from phase to phase. In the early stages of implementation, teachers' needs center around their concerns over the technology itself: CPUs, disk drives, software, etc. Technical training is a key ingredient to successful adoption. But as evolution proceeds, teachers increasingly need opportunities think about instruction and learning: to confront their actions and examine their motives; to bring their beliefs to the

PHASE	EXPECTATION	SUPPORT
Entry	•Identification of volunteer team •Installation of critical mass of technology to make it a constant feature of the classroom	•Provide advance planning time to develop shared vision •Provide daily, team planning time as permanent feature of schedule •Excuse staff from as many district requirements as possible •Create opportunities for staff to share experiences with non-participant colleagues
Adoption	•Maintenance of established instructional patterns and course of study •Use of word processors for writing •Use of CAI software for drill and practice of basic skills	•Provide nuts and bolts technical support to develop teacher's confidence and ability to maintain hardware and facilitate childrens' use •Provide CAI and word-processor software training
Adaptation	•Smooth integration of word processing and CAI software into existing instructional program resulting in increased teacher and student productivity •Modifications in course of study to take advantage of time opened by increase in productivity	•Develop flexible schedule to permit peer observation and team teaching •Introduce and discuss alternative pedagogies •Train staff in use of tool software: spreadsheets, databases, graphics, HyperCard, communications •Introducte videodisk and scanner technology
Appropriation	•Experimentation with interdisciplinary project-based instruction •Experimentation with team teaching •Experimentation with student grouping •Experimentation with scheduling	•Routinize peer observations and group discussions of events and consequences •Re-examine project mission and goals •Build awareness of alternative student assessment strategies, i.e., performance-based assessment and portfolio assessment strategies •Encourage and support conference attendance and teacher presentations
Invention	•Implementation of integrated curriculum •Balanced and strategic use of direct teaching and project-based teaching •Integration of alternative modes of student assessment	•Encourage collaboration between teachers and researchers •Encourage teachers to write about and publish their experiences •Explore telecommunications as way to keep teachers in contact with innovators outside of district •Create opportunities for teachers to mentor other teachers

Table 2: Support for Instructional Evolution in Technology-Intensive Environments

surface; and to critically reflect on the consequences of their choices, decisions, and actions. They need opportunities for ongoing dialogue about their experiences and for continuous development of their abilities to imagine and discover more powerful learning experiences for their students.

There are important caveats to the strategy of focusing on changing teachers' beliefs as a condition for instructional change. First, the strategy risks making successful change efforts a matter of achieving a series of personal triumphs rather than recognizing the process as an organizational, systemic, or cultural phenomenon. Any teacher in the process of change, after all, is an actor surrounded by other actors and institutionalized principles. If there is no change in the larger system, the struggling teacher and the innovation is doomed to frustration or abandonment (Bowers, 1973; Schiffer, 1979). Second, beliefs are an inherently messy concept. Rational planners must accept that beliefs, tied as they are to personal insights, significant personal moments, and to significant others, affect behavior in outwardly irrational ways. "There are no clear logical rules for determining the relevance of beliefs to real world events and situations" (Nespor, 1987, p. 321). Third, groups bound by commitment to change, sharing reflections and shaping new beliefs, can lose their objectivity. Here, too, the results can be devastating (Dwyer, 1981; Hoffer, 1951; Janis, 1972; Smith & Dwyer, 1979).

Lastly, a caveat about our own treatment of beliefs in this paper: we treated beliefs mostly as a barrier to change. We want to reemphasize our view that instructional evolution is not a matter of abandoning beliefs but of gradually replacing them with more relevant beliefs shaped by experiences in an altered context. Beliefs are a source of guidance in times of uncertainty; they "play a major role in defining teaching tasks and organizing the knowledge and information relevant to those tasks" (Nespor, p. 324). They are an irreplaceable element in the process of imagining alternative futures—"envisioning and trying to establish instructional formats or systems of classroom relations of which there is no direct personal experience" (Nespor, p. 319).

In sum, instructional change can only proceed with a corresponding change in beliefs about instruction and learning. Teachers' beliefs can only be modified while they are in the thick of change, taking risks and facing uncertainty. Teachers bold enough to participate in these efforts require and deserve modifications in their organizations' structure: alterations that

permit and encourage peer observation, dialogue, and reflection. Most importantly, they must have a way to gain continued assurance that their struggles are worthwhile.

Bringing significant change to the way we *do* schooling is a complex proposition fraught with setbacks. The experience of the ACOT project demonstrates the value of taking a long-term perspective on change and making the necessary personal and organizational commitments to bring about that change. To the observer, hoping for quick evidence of the efficacy of innovations, computers or otherwise, the process can only be frustrating and inconclusive. To those dedicated enough to make the commitment, the process can be very rewarding.

Reference List

Argyris, C. (1976). Increasing leadership effectiveness. New York: Wiley-Interscience.

Argyris, C., & Schön, D. A. (1974). Theory in practice: Increasing professional effectiveness. San Francisco: Jossey-Bass.

Baker, E. L., Herman, J. L., & Gearhart, M. (1989). The ACOT report card: Effects on complex performance and attitude. Paper presented at the meeting the American Education Research Association, San Francisco.

Baldridge, B. J., & Deal, T. E. (1975). Managing change in educational organizations. Berkeley: McCutchan Publishing Corporation.

Beaty, J., Howell, R., Shofner, A., & Wilmore, F. (1988). Nashville ACOT 1987-1988 report. Nashville.

Becker, H. J. (1987, July). The impact of computer use on children's learning: What research has shown and what it has not. Baltimore, MD: Center for Research on Elementary and Middle Schools.

Berman, P., & McLaughlin, M. W. (1976). Implementation of educational innovation. Educational Forum, 40(3), 345-370.

Bowers, D. G. (1973). OD techniques and their results in 23 organizations: The Michigan ICL study. Journal of Applied Behavioral Science, 9, 21-41.

Buber, M. (1957). Between man and man. Boston: Beacon Press.

Callahan, R. E. (1962). The cult of efficiency. Chicago: The University of Chicago Press.

Cancian, F. (1967). Stratification and risk taking: A theory tested on agricultural innovation. American Sociological Review, 32(6), 912-927.

Chin, R., & Benne, K. D. (1961). General strategies for effecting changes in human systems. In W. G. Bennis, K. D. Benne, & R. Chin (Eds.), The planning of change. New York: Holt, Rinehart & Winston.

Clark, C. M., & Peterson, P. L. (1986). Teachers' thought processes. In M. C. Wittrock (Ed.), Third handbook on research on teaching (3rd edition). New York: McMillan Publishing Company.

Cuban, L. (1990). Reforming again, again, and again. Educational Researcher, 19(1), 3-13.

Cuban, L. (1986). Teachers and machines: The classroom use of technology since 1920. New York: Teachers College Press.

Damarin, S., & Bohren, J. (1987). The evolution of the ACOT-Columbus classroom. In S. Damarin, & J. Bohren (Eds.), Reaching for tomorrow: A study of a computer-saturated classroom. Unpublished manuscript.

Dewey, J. (1963). Experience and education. New York: Collier Books.

Dwyer, D. C. (1981). Ideology and organizational evolution: A comparative study of two innovative educational projects. Unpublished doctoral dissertation, Washington University, St. Louis, MO.

Eisner, E. (1979). The educational imagination: On the design and evaluation of school programs. New York: MacMillan.

Fenstermacher, G. (1979). A philosophical consideration of recent research on teacher effectiveness. In L. S. Shulman (Ed.), Review of research in education. 6 (pp. 157-185). Itasca, IL: Peacock.

Fisher, C. F. (1988). The influence of high computer access in school work and student empowerment: An exploratory study. Unpublished report.

Fullan, M. (1982). The meaning of educational change. New York: Teachers College Press.

Giacquinta, J. B. (1973). The process of organizational change in schools. In F. N. Kerlinger (Ed.), Review of Research in Education, 3 (pp. 178-208). Itasca, IL: Peacock.

Glaser, B., & Strauss, A. (1967). The discovery of grounded theory. Chicago: Aldine Publishing Co.

Greene, M. (1979). Teaching: the question of personal reality. In A. Lieberman & L. Miller (Eds.), Staff development: new demands, New realities, new perspectives, (pp. 23-35). New York: Teachers College, Columbia University.

Gross, N., & Herriott, R. E. (Eds.). (1979). The dynamics of planned educational change. Berkeley: McCutchan.

Hamilton, D., MacDonald, B., King, C., Jenkins, D., & Parlett, M. (1977). Beyond the numbers game. London: MacMillan Education Ltd.

Herman, J. (1988). The faces of meaning: What do teachers, students and administrators think is happening in ACOT? Paper presented at the meeting of the American Education Research Association, New Orleans.

Hiebert, E. (1987). Report on the writing program at ACOT's Cupertino site. Unpublished report.

Hoffer, E. (1951). The true believer: thoughts on the nature of mass movements. New York: Perennial Library Harper & Row, Publishers.

Janis, I. (1972). The victims of group think: a psychological study of foreign-policy decisions and fiascoes. Boston: Houghton Mifflin Company.

Kitabchi, G. (1987). Final report for the evaluation of the Apple Classroom of Tomorrow project: Phase II. Memphis: Memphis City Schools, Division of Research Services.

Knupfer, N. N. (1988). Teachers' beliefs about instructional computing: Implications for instructional designers. Journal of Instructional Development, 11(4), 29-38.

Levine, H. (1988). Computer-intensive school environments and the reorganization of knowledge and learning: A qualitative assessment of Apple Computer's classroom of tomorrow. Paper presented at the meeting of the American Education Research Association, New Orleans.

Lieberman, A., & Miller, L. (1979). The social realities of teaching. In A. Lieberman & L. Miller (Eds.), Staff development: New demands, new realities, new perspectives, (pp. 54-68). New York: Teachers College, Columbus University.

Lieberman, A., & Shiman, D. A. (1973). The stages of change in elementary school settings. In C. M. Culver & G. J. Hoban (Eds.), The power to change: Issues for the innovative educator. New York: McGraw-Hill.

Lortie, D. C. (1975). Schoolteacher. Chicago: University of Chicago Press.

McLaughlin, M. W., & Marsh, D. D. (1979). Staff development and school change. In A. Lieberman & L. Miller (Eds.), Staff development: New demands, new realities, new perspectives, (pp. 69-94). New York: Teachers College, Columbia University.

Metz, M. H. (1988). Some missing elements in the educational reform movement. Educational Administration Quarterly, 24(4), 446-460.

Munby, H. (1982). The place of teachers' beliefs in research on teacher thinking and decision making, and an alternative methodology. Instructional Science, 11, 201-225.

Nespor, J. (1987). The role of beliefs in the practice of teaching. Journal of Curriculum Studies, 19(4), 317-328.

Nisbet, R. I., & Collins, J. M. (1978). Barriers and resistance to innovation. Journal of Teacher Education, 3(1), 2-29.

Olson, J. K. (1981). Teacher influence in the classroom. Instructional Science, 10, 259-275.

Paul, D. A. (1977). Change processes at the elementary, secondary and post secondary levels of education. In N. Nash & J. Culbertson (Eds.), Linking processes in educational improvement: Concepts and applications, (pp. 7-73). Columbus, OH: University Council for Educational Administration.

Phelan, P. (1989). The addition of computers to a first-grade classroom: A case study of two children. Unpublished report.

Phelan, P. (1988). Case studies of elementary school computer intensive classrooms: Cupertino and Nashville. Unpublished report.

Prawat, R. S. (1989). Promoting access to knowledge, strategy, and disposition in students: A research synthesis. Review of Educational Research, 59(1), 1-42.

Raywid, M. A. (1988). Restructuring school governance: Two models. Unpublished paper, Hofstra University, Hempstead, NY.

Rokeach, M. (1975). Beliefs, attitudes and values. San Francisco: Jossey-Bass Publishers.

Ross, S., Smith, L., Morrison, G. R., & Erikson, A. (1989, Feb). Helping at-risk children through distance tutoring: Memphis ACOT. Technological Horizons in Education Journal (T.H.E.), 68-71.

Sandholtz, J. H., Ringstaff, C., & Dwyer David C. (1990). Teaching in high-tech environments: Classroom management revisited. Paper presented at the meeting of the American Education Research Association, Boston.

Schein, E. H. (1985). Organizational culture and leadership: A dynamic view(1st ed.). San Francisco: Jossey-Bass Publishers.

Schiffer, J. (1979). A framework for staff development. In A. Lieberman & L. Miller (Eds.), Staff development: New demands, new realities, new perspectives, (pp. 4-23). New York: Teachers College, Columbia University.

Sizer, T. R. (1984). Horace's compromise: The dilemma of the American high school. Boston: Houghton Mifflin Company.

Smith, B. O. (1963). Toward a theory of teaching. In A. A. Bellack (Ed.), Theory and research in teaching. New York: Bureau of Publications, Teachers College.

Smith, L. M., & Dwyer, D. C. (1979). Federal policy in action: A case study of an urban education project. Washington D.C.: Occasional Paper of the National Institute of Education.

Smith, L. M. (1978). An evolving logic of participant observation, educational ethnography and other case studies. In L. Shulman (Ed.), Review of research in education. Itaska, IL: Peacock.

Smith, L. M., Dwyer, D. C., Prunty, J. J., & Kleine, P. F. (1988). Innovation and change in schooling: History, politics, and agency. (Anatomy of educational innovation: A mid to long term re-study and reconstrual, Book 3). New York: The Falmer Press.

Smith, L. M., & Geoffrey, W. (1968). Complexities of an urban classroom. New York: Holt, Rinehart & Winston.

Tierney, R. (1987). The engagement of thinking processes: A preliminary study of selected Apple Classrooms of Tomorrow students. Unpublished report.

Tierney, R. (1988). The engagement of thinking processes: A two-year study of selected Apple Classrooms of Tomorrow students. Unpublished report.

Timar, T. (1989). The politics of school restructuring. Phi Delta Kappan, 71(4), 265-275.

Tyack, D. (1974). The one best system: A history of American urban education. Cambridge, MA: Harvard University Press.

U.S. Congress Office of Technology Assessment. (1988). Power on! New tools for teaching and learning. Washington, DC: U.S. Government Printing Office.

Walker, J. P. (1987). Final evaluation report: Apple Classroom of Tomorrow (ACOT) program 1986-87. Columbus, OH: Columbus, Ohio Public Schools, Department of Evaluation Services.

Waller, W. (1952). The sociology of teaching. Chicago: University of Chicago Press.

Waugh, R. F., & Punch, K. F. (1987). Teacher receptivity to systemwide change in the implementation stage. Review of Educational Research, 57(3), 237-254.